



UNITED STATES PATENT AND TRADEMARK OFFICE

UNDER SECRETARY OF COMMERCE FOR INTELLECTUAL PROPERTY AND  
DIRECTOR OF THE UNITED STATES PATENT AND TRADEMARK OFFICE  
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Paper No

**Notice of Non-Compliant Amendment (37 CFR 1.121)**

The amendment filed on 5-6-03 is considered non-compliant because it has failed to meet the requirements of 37 CFR 1.121, as amended on September 8, 2000 (see 65 Fed. Reg. 54603, Sept. 8, 2000, and 1238 O.G. 77, Sept. 19, 2000). In order for the amendment to be compliant, applicant must supply the following omissions or corrections in response to this notice.

THE FOLLOWING ITEMS ARE REQUIRED FOR COMPLIANCE WITH RULE 1.121 (APPLICANT NEED NOT RE-SUBMIT THE ENTIRE AMENDMENT):

- ☐ 1. A clean version of the replacement paragraph(s)/section(s) is required. See 37 CFR 1.121(b)(1)(ii).
- ☒ 2. A marked-up version of the replacement paragraph(s)/section(s) is required. See 37 CFR 1.121(b)(1)(iii).
- ☐ 3. A clean version of the amended claim(s) is required. See 37 CFR 1.121(c)(1)(i).
- ☐ 4. A marked-up version of the amended claim(s) is required. See 37 CFR 1.121(c)(1)(ii).

Explanation: The specification can't be renumbered.

(LIE: Please provide specific details for correction to assist the applicant. For example, "the clean version of claim 6 is missing.")

For further explanation of the amendment format required by 37 CFR 1.121, see MPEP § 714 and the USPTO website at <http://www.uspto.gov/web/offices/dcom/olia/pbg/sampleaf.pdf>. A condensed version of a sample amendment format is attached.

- ☐ **PRELIMINARY AMENDMENT:** Unless applicant **supplies the omission or correction** to the preliminary amendment in compliance with revised 37 CFR 1.121 noted above within ONE MONTH of the mail date of this letter, examination on the merits may commence without entry of the originally proposed preliminary amendment. This notice is not an action under 35 U.S.C. 132, and this ONE MONTH time limit is not extendable.
- ☒ **AMENDMENT AFTER NON-FINAL ACTION:** Since the above-mentioned reply appears to be *bona fide*, applicant is given a TIME PERIOD of ONE MONTH or THIRTY DAYS from the mailing of this notice, whichever is longer, within which to **supply the omission or correction noted above** in order to **avoid abandonment**. EXTENSIONS OF THIS TIME PERIOD MAY BE GRANTED UNDER 37 CFR 1.136(a).

Theresa Steptoe

Legal Instruments Examiner (LIE)



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1	SPEC	13
2	LET.	3

Total number of pages: 16

Remarks:

Order of re-scan issued on .....



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## APPL PARTS

IMIS
Internal Misc. Paper
LET
Misc. Incoming Letter

371P  
 PCT Papers in a 371 Application  
 A...  
 Amendment Including Elections  
 ABST  
 Abstract  
 ADS  
 Application Data Sheet  
 AF/D  
 Affidavit or Exhibit Received  
 APPENDIX  
 Appendix  
 ARTIFACT  
 Artifact  
 BIB  
 Bib Data Sheet  
 CLM  
 Claim  
 COMPUTER  
 Computer Program Listing  
 CRFL  
 All CRF Papers for Backfile  
 DIST  
 Terminal Disclaimer Filed  
 DRW  
 Drawings  
 FOR  
 Foreign Reference  
 FRPR  
 Foreign Priority Papers  
 IDS  
 IDS Including 1449

NPL  
 Non-Patent Literature  
 OATH  
 Oath or Declaration  
 PET.  
 Petition  
 RETMAIL  
 Mail Returned by USPS  
 SEQLIST  
 Sequence Listing  
 SPEC 13  
 Specification  
 SPEC NO  
 Specification Not in English  
 TRNA  
 Transmittal New Application

CTNF  
 Count Non-Final  
 CTRS  
 Count Restriction  
 EXIN  
 Examiner Interview  
 M903  
 DO/EO Acceptance  
 M905  
 DO/EO Missing Requirement  
 NFDR  
 Formal Drawing Required  
 NOA  
 Notice of Allowance  
 PETDEC  
 Petition Decision

## OUTGOING

CTMS
Misc. Office Action

1449  
 Signed 1449  
 892  
 ABN  
 Abandonment  
 APDEC  
 Board of Appeals Decision  
 APEA  
 Examiner Answer  
 CTAV  
 Count Advisory Action  
 CTEQ  
 Count Ex parte Quayle  
 CTFR  
 Count Final Rejection

## INCOMING

AP.B  
 Appeal Brief  
 C.AD  
 Change of Address  
 N/AP  
 Notice of Appeal  
 PA..  
 Change in Power of Attorney  
 REM  
 Applicant Remarks in Amendment  
 XT/  
 Extension of Time filed separate

### Internal

SRNT  
 Examiner Search Notes  
 CLMPTO  
 PTO Prepared Complete Claim Set

ECBOX  
 Evidence Copy Box Identification  
 WCLM  
 Claim Worksheet  
 WFEE  
 Fee Worksheet

### File Wrapper

FWCLM  
 File Wrapper Claim  
 IIFW  
 File Wrapper Issue Information  
 SRFW  
 File Wrapper Search Info

JUN 05 2003

~~CONDUCTED HEAT VECTOR SENSOR~~

## BACKGROUND OF THE INVENTION

A common requirement in molding and casting processes is to measure the flow of heat from the molded or cast object, through the body of the mold to a liquid coolant or to the outside air. This is a difficult measurement to make, because:

1. most molding and casting processes involve very high temperatures;
2. the casting or molding process environment is extremely dirty, often electrically noisy;
3. molds are typically made of solid metal with high thermal conductivity; and
4. typical commercially available heat flux sensors have low thermal conductivity.

U.S. Patent 5,360,051, issued to Takahashi et al, describes a typical requirement for heat flux measurements in a continuous casting process. The solution offered by the patentee is to embed thermocouples in the wall of the mold. Heat flux through the mold may be calculated from the signals of these thermocouples, which indicate temperatures of the mold body at various points. Heat flux is calculated using measured or assumed values of the mold's thermal properties.

An alternative to the thermocouples of Takahashi et al would be a plug-type heat flux sensor as described by Liebert et al in U. S. patents 5,048,973, 5,086,204 and 5,314,247. The sensor described in these patents is an isolated plug directly machined into the wall of a vessel, optimally by electro-discharge machining, with thermocouples placed at various depths on the outer surface of the isolated plug. Heat flux is calculated from temperature data derived from the thermocouples, using a temperature variant thermal property inverse heat conductive problem method. These calculations of heat flux are extremely susceptible to electrical noise in the thermocouple signals. Any error in locating the thermocouples on the plug surface translates directly into an error in the heat flux calculation. The insulating gap between the instrumented

plug and the surrounding material allows the plug temperature profile to depart from that in the surrounding material, depending on conditions at the open end of the plug. This can produce large errors.

5 An alternative to these methods would be to apply heat flux sensors to the surface of the mold. Such sensors are described in U. S. Patent 4,567,365 issued to Degenne, U. S. Patent 5,990,412 issued to Terrell, and U. S. Patent 6,278,051, issued to Peabody. Heat flux sensors based on the teaching of these patents are commercially available, but they are not suitable for measurements in molding and casting processes. Their attachment to the outer surface of a mold adds a large  
10 local thermal resistance which causes heat to be shunted around the area covered by the sensor. The resulting measurements may be inaccurate as well as sensitive to local air currents and other conditions, and the sensors themselves are vulnerable to damage.

Ideally the flow of heat in a casting or molding process would be measured by a thermopile-type  
15 heat flux sensor imbedded in the mold itself. However, if the thermal conductivity of such a sensor were greatly different from that of the surrounding material, the pattern of heat flow through the mold would be distorted in the region of the sensor. This would produce a systematic error in the heat flux measurement. Thus it would be important for the sensor's thermal conductivity to nearly match that of the mold. Also, voids or air spaces could not be  
20 introduced into the mold when the sensor is installed, because these would produce even more serious distortions of the heat flow in the region of the sensor.

The conventional way to achieve good noise immunity for a thermopile-type heat flux sensor is to raise its output voltage by increasing the temperature drop it introduces into the heat flow path.  
25 While this approach is acceptable in radiative heat flux measurements, it cannot be used for conductive heat flux measurements because of the large error it produces. When the thermal conductivity of an imbedded sensor is made approximately equal to that of the mold, the only ways to increase the heat flux signal are by increasing the number of thermocouple pairs or by increasing their physical separation in the direction of heat flow. Space is not often available for

the large sensor that would be required.

U. S. Patent 4,779,994, issued to Diller et al, teaches the application of a thin film thermopile heat flux sensor to a surface, for measurement of convective or radiative heat flux through the surface. The output voltage of these sensors is small despite their construction with hundreds of thermocouple pairs, because the thermal resistance they place in the path of heat flow is extremely small. Typically the resistive element consists of one micron ( $10^{-6}$  meter) of a ceramic such as silicon monoxide. The thin films of these sensors are vulnerable to damage by abrasion and chemical attack, so they would not be suitable for the molding and casting environment.

#### **SUMMARY OF THE INVENTION**

A sensor designed for measurement of conducted heat flux passing through a solid object consists of a thin film thermopile deposited on a plane surface of a thin rectangular substrate. The thermopile is protected by being covered by a thin rectangular plate of the same material as the substrate. The sensor fits tightly in a slot in a threaded plug. For a measurement of heat flux in the solid object the threaded plug is imbedded in the solid object. Thermal properties of the substrate, the plate and the threaded plug match those of the solid object. When heat flows through the solid object the output voltage of the thermopile indicates the magnitude of the heat flux vector along the thermopile axis. Because the thermal properties of the substrate, plate and plug match those of the solid object, there is minimal deviation of the heat flow pattern from that which would have existed without the sensor present.. Accurate and precise measurements of heat flux are the result. Applications include measurement of heat flux in casting molds, boiler tubes, well surveying instruments and laser weapons testing.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

Figure 1 shows a system for measuring the heat flow in a solid body such as a metal casting

mold. Figure 2 is a sectional view of a conductive heat transfer sensor installed in a threaded hole in a mold. Figure 3 is a sectional view of a sensor. Figure 4 shows details of the threaded body of the sensor. Figure 5 shows tools for opening the slot in the sensor body to install the sensing substrate and cover, and for tightening the sensor in its blind threaded hole in the mold. Figure 6 shows the sensing insert, consisting of two flat plates fabricated from an electrically insulating material. Figure 7 shows the lower plate, with its heat flux sensing pattern of thermocouples. Figure 8 shows the upper plate that protects the sensing pattern from abrasion and chemical attack.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT OF THE INVENTION

Referring now to Figure 1, a system 1 for measuring heat flow in a solid body is shown, consisting of a conductive heat transfer sensor 2 and a voltage indicating meter 3, with interconnecting wires 4 and 5. The sensor 2 is installed in a blind hole in a casting mold 6 to measure heat transfer in the body of the mold. The sensor produces a voltage that is proportional to the rate of heat flow per unit area in the direction of the sensor axis 7. This voltage is indicated by the meter 3, whose scale may be graduated in conventional heat flux units such as watts/cm<sup>2</sup> or BTU/ft<sup>2</sup>-sec. In the preferred embodiment of the invention, the thermal conductivity and thermal diffusivity of the sensor materials are nearly equal to corresponding values for the material of the mold itself. When this is so, insertion of the sensor 2 does not change the amount or pattern of heat flow in the mold, and an undisturbed, accurate measurement of heat flow is achieved.

Figure 2 shows how the conductive heat transfer sensor 2 fits into the blind threaded hole 8 in the mold 6. In the preferred embodiment, the hole 8 has a flat bottom 9, and the end 10 of the sensor 2 is also flat. This arrangement results in an area contact between the end of the sensor and the bottom of the hole, facilitating heat transfer from the mold to the sensor with minimum temperature drop. It also minimizes the air space at the end 10 of the sensor.